4-1983

Disco Users Manual

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DYSCO USERS MANUAL

by

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A Thesis submitted
in partial fulfillment of
the course requirements for
The Bachelor of Science Degree

Western Michigan University
Kalamazoo, Michigan
April, 1983

ABSTRACT

The object of this thesis was to prepare an introductory user's manual for the use of DYSCO on WMU's DEC-10 computer. DYSCO is a process simulation program obtained from the Institute of Paper Chemistry. A variety of imaginary process systems were simulated with the DYSCO program so difficulties and problems could be found and dealt with. The manual gives examples and explanations so the program may be used with little difficulty.

This paper, however, provides only an introduction for the use of DYSCO, some of the more complicated routines such as RECIPE, CONTRL and VALVE should be studied at greater length. An attempt should be made to contact the writers of these sub programs rather then using trial and error methods to learn operation.

Keywords : Simulation; Manual; Education; Computers; Models.

T A B L E   O F   C O N T E N T S

INTRODUCTION

DYSCO, simplified from DYnamic Simulation and COntrol is a computer simulation program designed by Luis Lopez at the University of Michigan for use in the petrochemical industry. The program has been modified extensively by the Institute of Paper Chemistry for use in the pulp and paper industry. The modified program was put on line on Western Michigan University's DEC-10 computer in December of 1980.

This modified version is well suited for simulation of pulp and paper wet-end mass and energy balance problems. It can simulate flow of water, fiber and filler very well but is not suited for simulating processes involving chemical reactions or complex energy balances.

This manual is intended as a guide to use of the DYSCO program as implemented on WMU's DEC-10 computer. It is directed toward users with an understanding of process systems, particularly in the pulp and paper industry, but not necessarily having an extensive background in computers. Users attempting to model very complicated systems or desiring more detailed accounting of the program are directed to Lopez's thesis(1) on J. Newcombe's "DYSCO - An Overview".(2)

This manual gives directions translating a real system into a model, setting parameters for the model, and running through the simulation. Directions are intended to be very basic and directed towards the novice user.

PROCESS SIMULATION

Process simulation is defined as the designing and developing of a mathematical logical model of a system and conducting experiments with the model on a digital computer. Mathematical equations are used to form models of real physical systems and designed to perform as closely as possible to the real system. Systems are simulated as follows: 1) structure the system; 2) determine the key components; 3) study the key components; 4) integrate the key components into a descriptive model; 5) apply systems analysis and experimentation.(3)

Process models need to be classified in order to select the correct simulation package since no one simulation package is correct for all problems. Processes may be discrete or continuous range of values as in temperature. Steady state processes do not change with time. Dynamic processes vary with time. In deterministic processes a known input produces a known output. In a stochastic process a fixed input gives a random output. Papermaking is a continuous, dynamic and stochastic process.(4)

Dynamic process simulators involve the solution of differential equations. There are a variety of ways to solve differential equations with the best method depending on the structure of the system of equations and the values of the various models parameters may assume. Therefore, a dynamic process simulation package must have a variety of solution procedures available to the user.

Analysis of stochastic processes is much too difficult for simulation packages. The random behavior of stochastic processes is ignored to simplify, and the process is assumed to be deterministic for simulation for simulation procedures.

APPLICATION OF PROCESS SIMULATIONS

Process simulations help us understand complex process systems during design and operation. Potential benefits include: 1) improved methods of operation, efficiency, quality and production compacity; 2) reduced material losses, energy and chemical requirements; 3) definitions of capacity limitations and equipment require ments; 4) reduced water and effluent treatment requirements; 5) increased flexibility and control of operations.[5]

Simulation also enhances understanding of operating costs and economics, optimizing process system profitability, and investment evaluations. Decision making is aided by simulation by identifying probable results without actually implementing costly physical changes.

Process simulations minimize engineers' time, accumulating a great deal of available knowledge in their data banks for later use by others. Simulation shows interrelationships and impacts by studying systems rather than units.

An example of simulation could be modeling a CEDED (chlorine-extraction-chlorine dioxide-extraction-chlorine dioxide) bleach plant.[6] Each of the five towers was modeled separately. These are connected during the simulation for study of the system as a whole.

Here at Western Michigan University successful simulations of the Lou Calder pilot plant machine have been accomplished. In 1982 S.R. Tremont modelled the pilot plant machine at three different wire speeds and obtained results very close to experimental values.[7] Tremont also simulated closing the pilot plant system without ever having to implement the closed system. The simulation showed such effects as heat and solids buildup as would happen if the system were really closed. In 1983 Nick Triantafillopoulos used a slightly different DYSCO model to simulate effects of retention aid on the pilot plant machine. Here, also, the simulation data correlated with experimental results.[8]

THE DYSCO SIMULATOR

DYSCO (DYnamic Simulation and COntrol) is a dynamic modular simulator that attempts to solve the process in a simultaneous manner by appropriate storage of values for the new point in time. Two types of modules are available. Instantaneous models are identical to steady state models in that inputs are algebraically related to outputs. Dynamic models are represented by the standard mass equation:

$$\frac{d(V\cdot C)}{dt} = (Q\cdot C)in - (Q\cdot C)out = R\cdot V$$

V is the volume of the vessel.

C is the concentration of species.

Q is the volumetric flow rate.

R is the rate of appearance (disappearance) of species by some conversion process.

t is time.

Each dynamic module calculates its own vector of derivatives and passes them to a numerical integrator. The integrator then returns an updated vector of concentrations.

DYSCO is structured in two distinct FORTRAN programs, DYSCO1 and DYSCO2. Communication between the two occurs through data file (See Appendix II). DYSCO1 performs the preliminery tasks of accepting the flowsheet and the number of components. This sets up calls to the process models and dimensions needed for computer usage. DYSCO2 depends upon this FORTRAN code generated by DYSCO1 and information supplied by the user for each simulation.

DYSCO1 asks for a flow sheet of unit modules called the process topology. This includes the name and number of each unit module and the numbers of the associated input and output streams. The program checks for such mistakes as duplicate stream numbers and offers the user a chance for modification of the topology. Input, output and unused stream numbers are printed in DYSCO1. Finally, the process topology is placed in an output file.

DYSCO2 reads this process topology and does the actual simulation. User information entered here includes the names and code numbers of stream components, the unit module parameters, the properties and compositions of streams, the initial condition of the system and other control information. Lastly, DYSCO2 conducts the actual simulation with user control. Five integration methods are available. Fuler's method is most common. The other methods are the variable step Adams-Moultan, a fourth order Runge-Kulta, a fourth order, variable step Runge Kulta, and the Treaner method.

UNIT MODULES

Unit modules are subprograms which represent unit operations. Western Michigan University's DEC-10 computer has 13 of these unit modules. Unit module parameters are numbers entered by the user to constrain the unit operations. These are specified in Appendix 1 (Unit Module Documentation).

It is possible for advanced users of DYSCO to write their own subprograms. Lopez's thesis (pp. 254-274) may be consulted for this feature.

STREAMS

Streams are connections between unit modules. Streams representing real pipes are called material streams. Other stream types include information streams and utility streams.

Pieces of information carried by streams are called stream parameters. Material stream parameters include termperature, pressure, mass flow rate, and the mass fraction of each component in the stream.

PULPAPER PHYSICAL PROPERTIES

Presently this portion of DYSCO is not very sophisticated. The program suggests temperature in degrees Kèlvin, pressure in atmospheres, and flow in mass per time. However, the user may select his own units with few constraints. One must remember all materials are handled mathematically as liquids, even fiber and and filler. This allows program models to carry unrealistic consistencies not possible in the real world. Pure fiber or filler can actually run through a process stream when simulating.

Pressure is carried through the topology unchanged except by the modules MIXER and DYSMIX. The user may enter pressure units as suits his interests (atm, psia, etc.) as long as the units are entered consistently.

Greater care should be taken with unit selection if a heat balance is to be considered as when the modules MIXER and HEATER are used. Presently there are only three heat capacities associated with the PULPAPER physical properties package as presented in the following table with the corresponding component codes.

Component	Code(s)	Heat Capacity kcal/M.T.- ^{o}C *
Water	10 - 19	1000
Fiber	20 - 29	330
Additives	30 - 39	200

*1000 kcal/M.T. - ^{o}C = 1 cal/gm - ^{o}C

For an example one might consider adding 10,000 cal/sec in HEATER to a flow of pure fiber of 1000 gm/sec. The program would calculate this as follows:

$$T = \frac{H}{MC} = \frac{1000 \text{ cal/sec}}{(.33 \text{ cal/gm} - {}^{\circ}\text{C})\ 1000 \text{ gm/sec}}$$

$$T = 30.3\ {}^{\circ}\text{C}$$

The three heat capacities remain constant at any temperature or pressure. This always gives a straight line relationship between energy addition or subtraction and degrees (Kelvin or Centigrade) of change. Although degrees Kelvin is shown on the print out the user may choose to use degrees Centigrade for convenience because freezing point and boiling point are not considered in the mathematical subroutines. This means water will not act as a solid or a vapor even at temperatures at which water cannot exist as a liquid.

WORKING WITH DYSCO ON WMU'S DEC-10

DYSCO is a highly interactive program that communicates with the user in a step-by-step method. Most of the program is self-explanatory if the user has knowledge of the use of physical properties, topology and unit parameters. The user is expected to refer often to Appendix I (Unit Module Documentation).

Users may enter DYSCO from a different file number when protection codes are lifted. Type RUN DYSCO1[61001,61000] for DYSCO1 and DO DYSCO.MIC[61001,61000] for DYSCO2.

PULPAPER UNIT MODULES

DYSSEP - This unit models a screen, filter, paper machine wire, or centrifugal cleaner.

DYSMIX - This unit models a T-pipe or mixing point.

DILUTR - This unit takes one input stream and dilutes it with another stream to a desired consistency of any set of components.

CONCNT - This unit models a screen, filter or paper machine wire. It differs from DYSSEP in that the concentration of only one component can be controlled.

VALVE - This routine models a parabolic control valve.

SAVALL - This unit models a disk type saveall. One input stream is normally divided into three output streams, clear filtrate, cloudy filtrate and a cake.

RGULTR - This unit regulates the flow of a particular component or the total flow of a stream. Material is added by the unit if needed.

MIXER - This unit serves a variety of purposes. It can:
(a) add multiple input streams together
(b) accumulate material
(c) add heat to the material in the mixer
(d) set up multiple output streams.

HEATER - This unit can mix several input streams together, then add a specific amount of heat or change the temperature.

FGEN - This unit is used to generate a sinusoidal, exponential, or pulse variation of any stream attribute or unit parameter as a function of time.

CONTRL - This unit is a general purpose proportional, integral and derivative controller. Any combination of the three actions can be used.

DYSTRB - This unit models a distribution manifold.

CONVAL - This unit sets a constant flow rate from a MIXER.

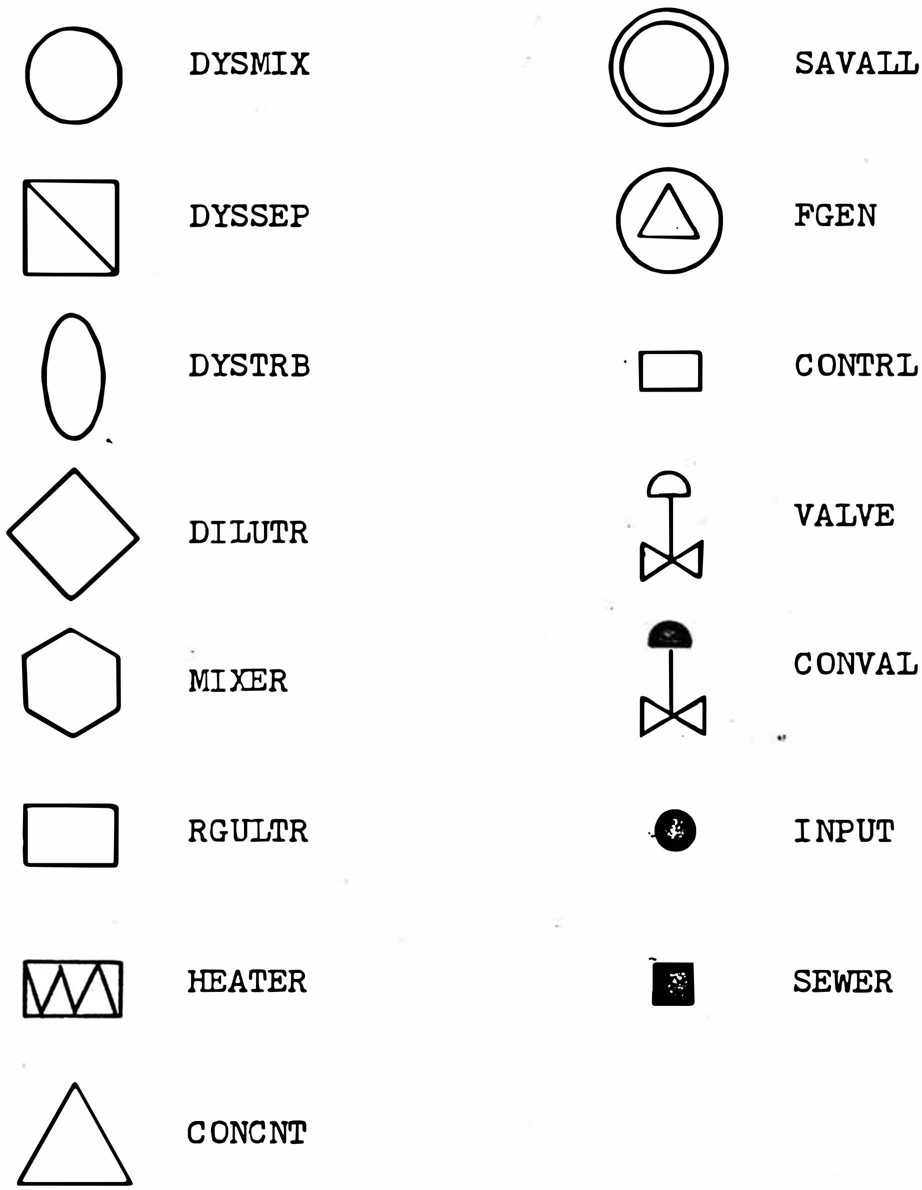

FIGURE 1

KEY FOR DYSCO MODULES

TOPOLOGY SET-UP

This portion (DYSCO1) transforms a real process into a system of DYSCO unit modules. Each portion of a process or piece of machinery may be modelled by a single DYSCO unit module or it may require several unit modules. Each module is assigned an individual unit number usually corresponding to its placement in the process. Each stream is also assigned an individual stream number. The unit modules in Appendix I should be carefully examined before the topology is entered.

For a simple example consider a two stage cleaning process for secondary fibers that removes fines optimally at a certain temperature. From the unit process Appendix we find DYSSEP models separators and HEATER raises temperature. The input stream is heated to the proper temperature and ran through the first cleaner, the accepts which are through. (See figure 2)

The three unit topology is entered in the computer as follows: UNIT NO. UNIT NAME = INPUTS, OUTPUTS(-)

1 HEATER = 1 -2

2 DYSSEP = 2 -3 -4

3 DYSSEP = 3 -6 -5

Note in unit 3 DYSSEP, -6 accepts stream is entered before -5 rejects stream as required by the DYSSEP unit module requirements.

SAMPLE TOPOLOGY

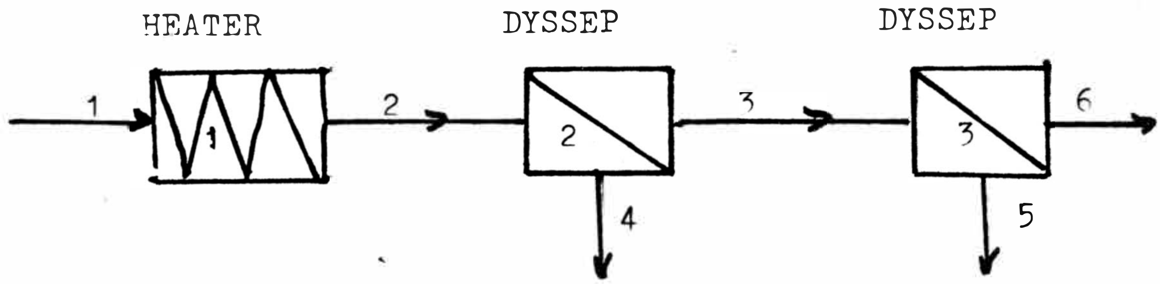

FIGURE TWO

PARAMETERS SELECTION

Parameter selection for unit modules simply requires referring to Appendix I for each unit in the topology. In the case of HEATER, 0 or 3 parameters are required, 3 parameters must be used with option 3 (heating a certain number of degrees) assuming constant feed temperature. Enter as:

OPTION = 3
DEGREE = 25
HEATADD = 0

The program will figure the heat/time added for later display.

In the case of DYSSEP the parameters are simply the fraction of each of the components in the input stream that remains in the accepts stream. This means the number of parameters in DYSSEP equals the number of components.

Enter for each DYSSEP if equal:

WATER = .9
FIBER = .9
FINES = .4
FILLER = .9

Other units require a great deal more consideration when deciding upon unit module parameters. Apendix I should be studied carefully before deciding upon parameters.

SAMPLE PROBLEM

The following is a DYSCO simulation of a purely hypothetical process designed to show aspects of the program pertinent to the user. A dummy stream has been added as an input to the MIXER to compensate for stream number one being lost in the stream matrix printout.

SAMPLE PROBLEM TOPOLOGY

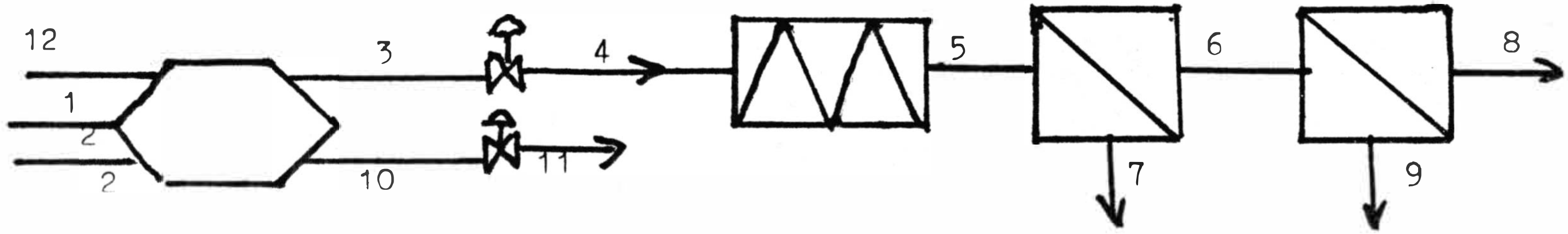

Figure 3

```
.RUN DYSCO1


***   DYSCO:  UNIVERSITY OF MICHIGAN DYNAMICS SIMULATION PROGRAM   ***
***   MODIFIED FOR PULP AND PAPER MILL SIMULATION BY
***   THE INSTITUTE OF PAPER CHEMISTRY
      **********************************************************
** ENTER:  A TITLE FOR THE PROCESS TO BE SIMULATED

MIXHEATSCREEN
```

TYPE IN AN ARBITRARY TITLE DESCRIPTIVE OF THE PROCESS

```
***   TOPOLOGY SECTION   ***
** ENTER:  THE TOTAL NUMBER OF UNITS IN THE SIMULATION

6

** ENTER IN ONE LINE:  UNIT NO.  UNIT NAME = INPUT (MINUS)OUTPUT
   STREAMS

1  MIXER = 1 2 12 -3 -10
2  CONVAL = 3 -4
3  HEATER = 4 -5
4  DYSSEP = 5 -6 -7
5  DYSSEP = 6 -8 -9
6  CONVAL = 10 -11
```

[Make sure to separate all entries by blanks. Inputs are positive. Outputs are negative. The order entered is important on some modules so Appendix I should be referred to.]

```
***   TOPOLOGY MATRIX   ***

    NUMBER     NAME    /          STREAMS
    ------     ----               -------

      1        MIXER         1     2     12    -3    -10
      2        CONVAL        3    -4      0     0      0
      3        HEATER        4    -5      0     0      0
      4        DYSSEP        5    -6     -7     0      0
      5        DYSSEP        6    -8     -9     0      0
      6        CONVAL       10   -11      0     0      0

    INPUT       UNIT       OUTPUT       UNIT       UNUSED
   STREAMS     NUMBER      STREAMS     NUMBER      STREAMS

      1          1            7          -4           0
      2          1            8          -5           0
     12          1            9          -5           0
      0          0           11          -6           0

** DO YOU WANT TO MODIFY THE TOPOLOGY?  ENTER:  YES OR NO
```

```
NO


END OF EXECUTION
CPU TIME:  0.38  ELAPSED TIME:   3:28.90
EXIT

.DO DYSCO.MIC   [After this user entry the computer links to
                 DYSCO2 and no user entry is required until
                 maximum simulation time.  Note:  During times
                 of heavy computer usage this link may take up
                 to ten minutes.]

.PATH SYS:=OLD:,STD:

.R OLD:FORTRA

*DMAIN.REL=DMAIN.FOR
DMAIN
*^C

.R LINK

*DYSCO2/OV/SA = DYSCO2,DMAIN/SPACE:9000/LINK
*/NODE:0 LINKA/LINK:A
*/NODE:0 LINKB/LINK:B
*/NODE:B LINKB1/LINK:B1
*/NODE:B LINKB2/LINK:B2
*/NODE:B LINKB3/LINK:B3
*/NODE:B LINKB4/LINK:B4
*/GO

EXIT

.RUN DYSCO2

***  DYSCO:  UNIVERSITY OF MICHIGAN DYNAMIC SIMULATION PROGRAM  ***
MODIFIED FOR PULP AND PAER SIMULATION BY THE INSTITUTE OF PAPER
CHEMISTRY

**********************************************************
   6    6
   1
MIXER      1     2    12     -3     -10
   2
CONVAL     3    -4     0      0       0
   3
HEATER     4    -5     0      0       0
   4
DYSSEP     5    -6    -7      0       0
   5
DYSSEP     6    -8    -9      0       0
   6
CONVAL    10   -11     0      0       0
```

*** TOPOLOGY MATRIX ***

NUMBER	NAME /	STREAMS				
1	MIXER	1	2	12	-3	-10
2	CONVAL	3	-4	0	0	0
3	HEATER	4	-5	0	0	0
4	DYSSEP	5	-6	-7	0	0
5	DYSSEP	6	-8	-9	0	0
6	CONVAL	10	-11	0	0	0

** ENTER: THE MAXIMUM TIME FOR SIMULATION AND THE INITIAL TIME STEP THE UNITS FOR TIME ARE ARBITRARY BUT MUST BE CONSISTENT THROUGHOUT (FOR EXAMPLE, IF YOUR TIME UNIT IS 1 HOUR, THEN FLOW RATES MUST BE IN MOLES/HR ETC.)

20 1

The selection for maximum time for simulation is not very critical because the user may extend it. A value 4 or 5 times larger than the value of the largest time constant in the process should be selected.

Initial time step must be small enough to insure that solutions will be both stable and accurate. A value about one tenth the smallest time constant is common.

** ARE THERE ANY INFORMATION STREAMS? (SUCH AS STREAMS TO OR FROM CONTROLLERS, CONTROL VALVES, RECORDERS, ETC.) ENTER: YES OR NO

NO If yes, the user enters stream numbers in one line separated by blanks

** ARE THERE ANY UTILITY STREAMS? (STEAM, COOLING WATER, ELECTRICAL LINES) ENTER: YES OR NO

NO This is currently not operational and should be answered with a no.

*** PHYSICAL PROPERTIES SECTION ***

** ENTER: THE PHYSICAL PROPERTY SYSTEM YOU ARE USING. (INTERNAL,PENNSYLVANIA,OR PULPAPER)

PULPAPER   Pulpaper is the physical property system obtained from the Institute of Paper Chemistry and the only physical property system implemented in this computer.

```
** ENTER:   THE TOTAL NUMBER OF COMPONENTS

4


** NUMBER OF COMPONENTS IN THIS SIMULATION =    4

** ENTER: ONE COMPONENT NUMBER AND NAME ON EACH LINE

10 WATER
20 FIBER
21 FINES
30 FILLER
```

[Refer to section on PULPAPER physical properties for correct component code. Note: Fines were given a code from 20-29 because of similar heat capacity to fiber]

```
***  UNIT PARAMETERS SECTION   ***
```

[REFER TO APPENDIX I]

```
   UNIT NO. ---     1
   NAME     ---   MIXER
ENTER IN ORDER LISTED--DO NOT SKIP ANY


** ENTER   8 PARAMETERS:  T(K), P(ATM), M(G.MOLES), EXTERNAL
HEAT FLUX AND MASS FRACTIONS IN THE SAME ORDER AS THE COMPONENTS


** ENTER: PARAMETER NAME     =     VALUE (ALL IN ONE LINE)
 PARAMETERS MUST BE IN ASCENDING ORDER

TEMP = 25
PRESSURE = 14.7
MASS = 2000
HEATFLUX = 0
WATER = 1
FIBER = 0
FINES = 0
FILLER = 0
```

[Ascending order is that proposed in Appendix I]

```
    UNIT NO. ---     2
    NAME     ---   CONVAL
```

```
** ENTER: THE TOTAL NUMBER OF PARAMETERS REQUIRED FOR THIS UNIT

1

** THE TOTAL NUMBER OF PARAMETERS =     1

** ENTER: PARAMETER NAME     =     VALUE (ALL IN ONE LINE)
 PARAMETERS MUST BE IN ASCENDING ORDER

FLOW = 1000


   UNIT NO. ---      3
   NAME     ---   HEATER

** ENTER: THE TOTAL NUMBER OF PARAMETERS REQUIRED FOR THIS UNIT

3

** THE TOTAL NUMBER OF PARAMETERS =     3

** ENTER: PARAMETER NAME     =     VALUE (ALL IN ONE LINE)
 PARAMETERS MUST BE IN ASCENDING ORDER

3


*** ERROR ***


** ERROR: EQUAL SIGN MISSED AFTER NAME. PLEASE RETYPE

OPTION = 3
DEGREES = 25
HEATADD = 0


    UNIT NO.  ---      4
    NAME      ---   DYSSEP

** ENTER: THE TOTAL NUMBER OF PARAMETERS REQUIRED FOR THIS UNIT

4

** THE TOTAL NUMBER OF PARAMETERS -     4

** ENTER: PARAMETER NAME     =     VALUE (ALL IN ONE LINE)
 PARAMETERS MUST BE IN ASCENDING ORDER
```

FLOW = 10

** UNIT PARAMETER VALUES AT TIME = 0.000

UNIT NO. --- 1
NAME --- MIXER

PARAMETER NO.	NAME		VALUE
2	TEMP	=	25.000000
3	PRESSURE	=	14.700000
4	MASS	=	2000.000000
5	HEATFLUX	=	0.000000
6	WATER	=	1.000000
7	FIBER	=	0.000000
8	FINES	=	0.000000
9	FILLER	=	0.000000

UNIT NO. --- 2
NAME --- CONVAL

PARAMETER NO.	NAME		VALUE
2	FLOW	=	1000.000000

UNIT NO. --- 3
NAME --- HEATER

PARAMETER NO.	NAME		VALUE
2	OPTION	=	3.000000
3	DEGREES	=	25.000000
4	HEATADD	=	0.000000

UNIT NO. --- 4
NAME --- DYSSEP

PARAMETER NO.	NAME		VALUE
2	WATER	=	0.900000
3	FIBER	=	0.900000
4	FINES	=	0.400000
5	FILLER	=	0.900000

```
   UNIT NO.   ---    5
   NAME       ---   DYSSEP

PARAMETER NO.       NAME                          VALUE

      2             WATER               =         0.900000
      3             FIBEER              =         0.900000
      4             FINES               =         0.400000
      5             FILLER              =         0.900000

   UNIT NO.   ---    6
   NAME       ---   CONVAL

PARAMETER NO.       NAME                          VALUE

      2             FLOW                =        10.000000


***  STREAM PARAMETERS SECTION  ***


** DO YOU WANT TO INITIALIZE ALL STREAMS SEPARATELY?

NO   [ This allows the user to start the simulation with non-
       zero values in non-input stream]

** DO YOU WANT TO PUT DEFAULT VALUES IN MATERIAL STREAMS IN SM
   ARRAY?

NO   [This allows the user to keep parameters constant in the
      stream matrix]
*THESE ARE THE INPUT STREAMS TO BE INITIALIZED.
 1   2   12

                 ** MATERIAL STREAMS  **
** ENTER:  T(K), P(ATM), FLOW(MASS/TIME), AND MASS FRACTIONS IN
THE SAME ORDER AS THE COMPONENTS (ALL IN ONE LINE SEPARATED BY
BLANKS)

** ENTER:  INFORMATION FOR STREAM    1

25 14.7 1000 .95 .04..01 .0

** ENTER:  INFORMATION FOR STREAM    2

25 14.7 10 0 0 0 1

** ENTER:  INFORMATION FOR STREAM   12

0 0 0 0 0 0 0
* ARE THERE ANY OTHER STREAMS YOU WANT TO INITIALIZE?

N
```

NO [RECIPE allows the user to apply step or ramp function changes to any stream or unit parameters at any time during the simulation. The sequencing of the changes is described in the input data before simulation begins in the form of "recipes". There are two types of recipes: unconditional and conditional. Changes can be specified to occur at some particular times with unconditional recipe or when some stream or unit parameters exceed upper or lower limiting values with conditional recipe.]

** DO YOU WANT TO ENTER ARBITRARY TABULAR FUNCTIONS? ENTER: YES OR NO

NO [This is not currently operational]

*** STREAM PARAMETERS MATRIX ***

** STREAM PARAMETER VALUES FOR TIME = 0.000

STR	T	P	Flow	X1	X2	X3	X4
1	25.0	14.7	1000	0.950000	0.040000	0.010000	0.000000
2	25.0	14.7	10	0.000000	0.000000	0.000000	1.000000
3	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000
4	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000
5	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000
6	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000
7	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000
8	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000
9	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000
10	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000
11	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000
12	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000

** DO YOU WANT TO PRINT STREAM PARAMETERS AT INTEGRAL MULTIPLES MULTIPLES OF THE INITIAL TIME STEP 1.00000 (YES) OR OF THE CURRENT TIME STEP (NO)?

```
** ARE ALL MATERIAL STREAMS LIQUID PHASE IN THIS SIMULATION?
ENTER: YES OR NO

YES   [PULPAPER can only handle liquid material streams]


***  CONVERGENCE CRITERIA SECTION  ***


** DO YOU WANT TO TEST FOR CONVERGENCE TO STEADY STATE DONDITIONS?
ENTER: YES OR NO

YES


** ENTER: TOTAL NUMBER OF STREAM PARAMETERS TO BE CHECKED FOR
CONVERGENCE

2


** ENTER: PARAMETER NAME    =    TOLERANCE FRACTION
POSSIBLE PARAMETERS : TEMP, PRESS, FLOW, OR COMPONENT NAME

TEMP = .01     [This stops the program when relative steady
FIBER = .01     state convergence criteria are met.  This happens
                when the relative fractional change over two
                successive integration steps is less than the
                given tolerance fraction.  Up to nine parameters
                may be tested for convergence.]


***  CONVERGENCE CRITERIA ***

          TEMP                .100000E-01
          FIBER               .100000E-01

** ENTER IN ONE LINE: THE UNIT CALCULATION ORDER

1 2 3 4 5 6   [Normally the order of calculation is according
                to the most logical direction of material flow.
                It specifies the stream order in which conver-
                gence criteria is going to be carried out.]

** CALCULATION ORDER
1  2  3  4  5  6
DATA BEING WRITTEN TO DEVICE   3


** DO YOU WANT TO USE RECIPE? ENTER: YES OR NO
```

** ENTER: PRINTING FREQUENCY

1

** ENTER INTEGRATION METHOD: 1=EULER, 2=RUNGE, 3=RUNGV, 4=ADAMSM, 5=TREANOR

1 [EULER: single step, fixed step size
RUNGE (4th order Runge Kulta): singles step, fixed step size
RUNGV (4th order Runge Kutla): single step, variable step size
ADAMSM (3rd order Adams Moulton): multist, predictor-corrector, variable size step
TREANOR: multistep, predictor-corrector, variable size step

In choosing an integration method EULER is a good bet for most average simulations, dynamic or steady-state, ADAMSM or TREANOR are desireable for systems with initially small time constants developing into larger time constants. For a detailled description the user is referred to Lopez's thesis pp. 125-182.]

** DO YOU WANT AN EXPLANATION OF THE COMMANDS: P,V,S,U,D,T,N,Z, X AND G? ENTER: YES OR NO

YES [These give the user control during the simulation]

** YOU ARE ALLOWED DURING THE SIMULATION TO:

- (P) ENTER A NEW PRINTING FREQUENCY AS A MULTIPLE OF INITIAL TIME STEP 1,00000
- (V) ENTER A NEW PRINTING FREQUENCY AS A MULTIPLE OF CURRENT TIME STEP
- (S) CHANGE STREAM PARAMETERS
- (U) CHANGE UNIT PARAMETERS
- (D) DISPLAY UNIT PARAMETERS
- (T) CHANGE INTEGRATION TIME STEP FOR EULER OR RUNGE
- (N) SPECIFY NO ADDITIONAL CHANGES AT THIS TIME
- (Z) SPECIFY NO ADDITIONAL CHANGES IN THE SIMULATION AND POSSIBLE REASSIGNMENT OF THE OUTPUT DEVICE FOR THE PRINTING OF THE STREAM PARAMETERS
- (X) STOP THE PROGRAM
- (G) CHANGE GRAPHICAL OUTPUT (GRAPHICS TERMINAL ONLY)

** ENTER COMMAND: P,V,S,U,D,T,N,Z,X, OR G

N

** DO YOU WANT TO PLOT STREAM OR UNIT PARAMETERS? (PLOTS DONE LATER)

NO [Plots are sent to Plot File 21 and cannot be recovered]

```
%FRSAPR Floating divide check    PC= 117171

%FRSAPR Floating divide check    PC= 117171
```

[This is telling us no heat can be added to an empty stream. The error shows in the stream matrix.]

```
** STREAM PARAMETER VALUES FOR TIME =        1.000

 STR     T    P        FLOW        X1        X2        X3         X4

  2   25.0 14.7          10 0.000000 0.000000 0.000000  1.000000
  3    8.2 14.7        1000 0.980066 0.013289 0.003322  0.003322
  4    8.2 14.7        1000 0.980066 0.013289 0.003322  0.003322
  5   26.0  0.0           0************************************
  6   26.0  0.0           0 0.000000 0.000000 0.000000  0.000000
  7   26.0  0.0           0************************************
  8   26.0  0.0           0 0.000000 0.000000 0.000000  0.000000
  9   26.0  0.0           0 0.000000 0.000000 0.000000  0.000000
 10    8.2 14.7          10 0.980066 0.013289 0.003322  0.003322
 11    8.2 14.7          10 0.980066 0.013289 0.003322  0.003322
 12    0.0  0.0           0 0.000000 0.000000 0.000000  0.000000

** ENTER COMMAND:  P,V,S,U,D,T,N,Z,X, OR G

N


** STREAM PARAMETER VALUES FOR TIME =        2.000

 STR     T    P        FLOW        X1        X2        X3        X4

  2   25.0 14.7          10 0.000000 0.000000 0.000000 1.000000
  3   13.7 14.7        1000 0.966822 0.022119 0.005530 0.005530
  4   13.7 14.7        1000 0.966822 0.022119 0.005530 0.005530
  5   33.2 14.7        1000 0.980066 0.013289 0.003322 0.003322
```

STR	T	P	FLOW	X1	X2	X3	X4
6	33.2	14.7	898	0.981879	0.013314	0.00.479	0.003328
7	33.2	14.7	101	0.964052	0.013072	0.019608	0.003268
8	33.2	14.7	807	0.982686	0.013325	0.000658	0.003331
9	33.2	14.7	90	0.074670	0.013216	0.008811	0.003304
10	13.7	14.7	10	0.966822	0.022119	0.005530	0.005530
11	13.7	14.7	10	0.966822	0.022119	0.005530	0.005530
12	0.0	0.0	0	0.000000	0.000000	0.000000	0.000000

```
** ENTER COMMEND: P,V,S,U,D,T,N,X,X, OR G

S

** ENTER: STREAM NUMBER

1

** ENTER: ALL... TO CHANGE ALL THE PARAMETERS
          PAR... TO CHANGE ONLY ONE PARAMETER AT A TIME

ALL

** ENTER: T(K),P(ATM),FLOW( MASS/TIME),AND MASS FRACTIONS IN THE
SAME ORDER AS COMPONENTS (ALL IN ONE LINE SEPARATED BY BLANKS)

OLD VALUES:
  25.000      14.70 1000.000     1.0      0.0      0.0      0.0
NEW VALUES ???

0 0 0 0 0 0 0

** DO YOU WANT TO MAKE MORE CHANGES AT THIS TIME? ENTER: YES OR NO

YES


** ENTER COMMAND: P,V,S,U,D,T,N,Z,X, OR G

S

 ** ENTER: STREAM NUMBER
```

```
12

** ENTER:   ALL... TO CHANGE ALL THE PARAMETERS
            PAR... TO CHANGE ONLY ONE PARAMETER AT A TIME

ALL

** ENTER: T(K),P(ATM),FLOW( MASS/TIME),AND MASS FRACTIONS IN THE
SAME ORDER AS COMPONENTS (ALL IN ONE LINE SEPARATED BY BLANKS)


OLD VALUES:
   0.000       0.00     0.000     0.0     0.0     0.0     0.0

NEW VALUES ???

25 14.7 1000 .95 .04 .01 0
```

[Stream 2 has been switched with stream 12 so it shows in the stream matrix.]

```
** DO YOU WANT TO MAKE MORE CHANGES AT THIS TIME? ENTER: YES OR NO

N


** STREAM PARAMETER VALUES FOR TIME =       3.000
```

STR	T	P	FLOW	X1	X2	X3	X4
2	25.0	14.7	10	0.000000	0.000000	0.000000	1.000000
3	17.4	14.7	1000	0.958021	0.027986	0.006997	0.006997
4	17.4	14.7	1000	0.958021	0.027986	0.006997	0.006997
5	38.7	14.7	1000	0.966822	0.022119	0.005530	0.005530
6	38.7	14.7	897	0.969801	0.022187	0.002465	0.005547
7	38.7	14.7	102	0.940809	0.021524	0.032286	0.005381
8	38.7	14.7	806	0.971131	0.022218	0.001097	0.005554
9	38.7	14.7	90	0.957992	0.021917	0.014611	0.005479
10	17.4	14.7	10	0.958021	0.027986	0.006997	0.006997
11	17.4	14.7	10	0.958021	0.027986	0.006997	0.006997
12	25.0	14.7	1000	0.950000	0.040000	0.010000	0.000000

** ENTER COMMAND: P,V,S,U,D,T,N,Z,X, OR G

P

** ENTER: THE NEW PRINTING FREQUENCY AS A MULTIPLE OF 1.00000

3 [This keeps the stream matrix from being printed each time.]

** OLD PRINTING FREQUENCY.... 1 NEW.... 3

** DO YOU WANT TO MAKE MORE CHANGES AT THIS TIME? ENTER: YES OR NO

NO

STR	T	P	FLOW	X1	X2	X3	X4
2	25.0	14.7	10	0.000000	0.000000	0.000000	1.000000
3	22.8	14.7	1000	0.945706	0.036196	0.009049	0.009049
4	22.8	14.7	1000	0.945706	0.036196	0.009049	0.009049
5	46.6	14.7	1000	0.948288	0.034475	0.008619	0.008619
6	46.6	14.7	895	0.952850	0.034641	0.003849	0.008660
7	46.6	14.7	104	0.909111	0.033050	0.049576	0.008263
9	46.6	14.7	91	0.934859	0.033986	0.022658	0.008497
10	22.8	14.7	10	0.945706	0.036196	0.009049	0.009049
11	22.8	14.7	10	0.945706	0.036196	0.009049	0.009049
12	25.0	14.7	1000	0.950000	0.040000	0.010000	0.000000

** ENTER COMMAND: P,V,S,U,D,T,N,Z,X, OR G

N

** STREAM PARAMETER VALUES FOR TIME = 12.000

STR	T	P	FLOW	X1	X2	X3	X4
2	25.0	14.7	10	0.000000	0.000000	0.000000	1.000000
3	24.8	14.7	1000	0.941034	0.039311	0.009828	0.009828
4	24,8	14.7	1000	0.941034	0.039311	0.009828	0.009828
5	49.7	14.7	1000	0.941256	0.039163	0.009791	0.009791
6	49.7	14.7	895	0.946404	0.039377	0.004375	0.009844
7	49.7	14.7	104	0.897329	0.037335	0.056002	0.009334
8	49.7	14.7	803	0.948710	0.039473	0.001949	0.009868
9	49.7	14.7	91	0.926144	0.038534	0.025689	0.009633
10	24.8	14.7	10	0.941034	0.039311	0.009828	0.009828
11	24.8	14.7	10	0.941034	0.039311	0.009828	0.009828
12	25.0	14.7	1000	0.950000	0.040000	0.010000	0.000000

```
** ENTER COMMAND: P,V,S,U,D,T,N,Z,X, OR G

D

** ENTER: UNIT NUMBER

1

** ENTER: ALL... TO DISPLAY ALL THE PARAMETERS
          PAR... TO DISPLAY ONLY ONE PARAMETER AT A TIME

ALL

    UNIT NO. ---    1
    NAME     ---   MIXER

PARAMETER NO.     NAME                                VALUE

   2            TEMP                   =          24.806987
   3            PRESSURE               =          14.700000
   4            MASS                   =        3009.999970
   5            HEATFLUX               =           0.000000
   6            WATER                  =           0.941034
   7            FIBER                  =           0.039311
   8            FINES                  =           0.009828
   9            FILLER                 =           0.009828
```

** DO YOU WANT TO MAKE MORE CHANGES AT THIS TIME? ENTER: YES OR NO

N

*** CONVERGENCE AT TIME 12.000 ***

** STREAM PARAMETER VALUES FOR TIME = 12.000

STR	T	P	FLOW	X1	X2	X3	X4
2	25.0	14.7	10	0.000000	0.000000	0.000000	1.000000
3	24.8	14.7	1000	0.941034	0.039311	0.009828	0.009828
4	24.8	14.7	1000	0.941034	0.039311	0.009828	0.009828
5	49.7	14.7	1000	0.941256	0.039163	0.009791	0.009791
6	49.7	14.7	895	0.946404	0.039377	0.004375	0.009844
7	49.7	14.7	104	0.897329	0.037335	0.056002	0.009334
8	49.7	14.7	803	0.948710	0.039473	0.001949	0.009868
9	49.7	14.7	91	0.926144	0.038534	0.025689	0.009633
10	24.8	14.7	10	0.941034	0.039311	0.009828	0.009828
11	24.8	14.7	10	0.941034	0.039311	0.009828	0.009828
12	25.0	14.7	1000	0.950000	0.040000	0.010000	0.000000

** DO YOU WANT TO CONTINUE WITH THE SIMULATION? ENTER: YES OR NO

[The simulation may be continued without convergence to steady slate.]

DATA BEING WRITTEN TO DEVICE 9

** DO YOU WANT TO DISPLAY ANY UNIT PARAMETERS? ENTER: YES OR NO

NO [The program will print unit parameters anyway.]

** UNIT PARAMETER VALUES AT TIME = 12.000

UNIT NO. --- 1
NAME --- MIXER

PARAMETER NO.	NAME		VALUE
2	TEMP	=	24,806987
3	PRESSURE	=	14,700000
4	MASS	=	3009,999970
5	HEATFLUX	=	0,000000
6	WATER	=	0.941034
7	FIBER	=	0.039311
8	FINES	=	0.009828
9	FILLER	=	0.009828

UNIT NO. --- 2
NAME --- CONVAL

PARAMETER NO.	NAME		VALUE
2	FLOW	=	1000.000000

UNIT NO. --- 3
NAME --- HEATER

PARAMETER NO.	NAME		VALUE
2	OPTION	=	3.000000
3	DEGREES	=	25.000000
4	HADDADD	=	23984.221200

UNIT NO. --- 4
NAME --- DYSSEP

PARAMETER NO.	NAME		VALUE
2	WATER	=	0.900000
3	FIBER	=	0.900000
4	FINES	=	0.400000
5	FILLER	=	0.900000

UNIT NO. --- 5
NAME --- DYSSEP

PARAMETER NO.	NAME		VALUE
2	WATER	=	0.900000
3	FIBEER	=	0.900000
4	FINES	=	0.400000
5	FILLER	=	0.900000

```
     UNIT NO ---     6
     NAME    ---   CONVAL

PARAMETER NO.      NAME                              VALUE

   2              FLOW                   =      10.000000

END OF EXECUTION
CPU TIME:  3.42  ELAPSED TIME:  28:26.12
EXIT
```

.K/f   [This saves the topology for future use so the user may start with DO DYSCO.MIC]

PROBLEMS ON THE DEC-10

There seems to be a problem with either the subroutines governing information streams, the unit CONTRL or the unit VALVE. The problem shows when the stream matrix array is printed after tiame t=o. Streams are lost completely and material shows up in information streams. Due to the many variables entered when using information streams, VALVE and CONTROL it was impossible to pinpoint the problem.

Unit routines MIXER and FGEN also lose streams in the printed stream matrix array. The streams do not show but the flows are still working in the system. With MIXER it is sometimes possible to enter a dummy stream (no flow) that is expected to be lost so all appropriate streams will be shown in the stream matrix array.

Although the program gives the user the choice to plot stream or unit parameters, these are sent to lot file 21 and are unable to be retrieved. This also happens at the end of the simulation when trying to save stream and unit parameters at some other time.

CONCLUSIONS

Process simulation has proved to be an effective tool for today's engineers. Users manuals will be needed as new programs are continually being developed.

I believe, however, that those more qualified in computer usuage write up these manuals. The trial and error method I used in studying the DYSCO program proved to be too time consuming for the results achieved.

RECOMMENDATIONS

I recommend further study and use of DYSCO at Western Michigan University. DYSCO has effectively simulated the Lou Calder pilot plant machine so DYSCO can be used here practically.

RECIPE, CONTRL, VALVE AND MIXER are subprograms that need further study. The writing of unit modules is another area of DYSCO that should be examined as these could be written especially for equipment here at Western Michigan University.

LITERATURE CITED

1. Lopez, LA. "DYSCO: An Interactive Executive Program for Dynamic Simulation and Control of Chemical Processes." Ph.D dissertation. University of Michigan, 1974

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3. Pritsker, Alan B. Lecture, W.M.U., October 1982

4. Parker, P.E. "DYSCO: a modular, dynamic simulator for the pulp and paper industry." TAPPI 64, No. 3, pp. 97-101

5. Thomas, K.U. "Process Simulation Program," TAPPI 62, No.2, pp. 51-57

6. Sklarewitz, M.L. and Parker, P.E. "Dynamic Model of a CEDED Bleached Plant" TAPPI, Vol. 64, No. 6

7. Tremont, S.R. "Closed Water Systems on Paper and Board Machines Using the DYSCO Simulation Program", Masters Thesis, Western Michigan University, April 1982

8. Triantafillopoulos, N.G. "Dynamic Simulation of the Paper Machine Wet End and Effects of Reteution Aid", Independent Study, Western Michigan University, April 1983

APPENDIX I

UNIT MODULE DOCUMENTATION

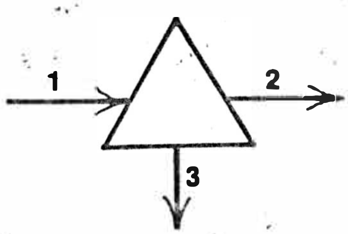
by the

Institute of Paper Chemistry

MODULE: CONCNT

PURPOSE: This unit models a screen, filter or paper machine wire. It differs from DYSSEP in that the concentration of only one component can be controlled. The user specifies the concentration of the controlled component in the first output stream as well as the fraction by weight of the controlled component in the input stream which is contained in the first output stream.

DIAGRAM:



TOPOLOGY: < unit no. > CONCNT = 1 -2 -3

UNIT PARAMETERS:

Number required = 3

Parameter No.	Description
1.	Number of stream parameter to be controlled in first output stream. (Component number plus seven.)
2.	Fraction of the weight of the designated component in the input stream to be output in the first output stream.
3.	Desired mass fraction of the controlled component in the first output stream.

COMMENTS:

1. Care must be taken to insure that if the controlled component is smaller in the controlled stream than in the input stream, enough flow is present to meet the needs of the particular case. If not, an error message is written to device 7, and the second output stream is set equal to 0.0.

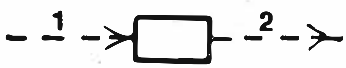
2. In the first output stream, which contains the controlled flow, all other components maintain their same relative levels.

3. The split is assumed to be isobaric and isothermal.

MODULE: CONTRL

PURPOSE: CONTRL is a general purpose proportional, integral, and derivative controller. Any combination of the three actions can be used.

DIAGRAM:



TOPOLOGY: < unit number > CONTRL = 1 -2

UNIT PARAMETERS:

Number required = 6

Parameter Number	Description
1.	Proportional band = 100/Gain
2.	Derivative Constant
3.	Reset constant (units of 1/time)
4.	Set point
5.	Range of action
6.	Attribute of input stream which is being controlled.

COMMENTS:

1. The input to the controller is an information stream which contains all attributes of a stream or information about the unit to be controlled. The controller then calculates an error as:

$$E = \frac{\text{Signal} - \text{Set Point}}{\text{Range}}$$

This error is tranformed into an output signal as:

$$Y = \text{Gain} \cdot E + \text{Reset} \cdot \int_0^t E\,dt + (\text{Derivative Constant}) \cdot \frac{dE}{dt}$$

the output signal is then mapped on the range 0 to 100 by:

If $Y \leq 0$ then $Y = 0$.

$\emptyset < Y \leq 100$ then $Y = Y$.

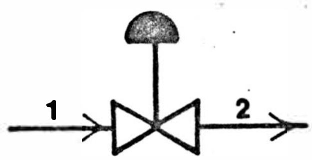
$Y < 100$, then $Y = 100$.

The signal is then put into the output stream.

MODULE: CONVAL

PURPOSE: CONVAL acts as a pump, valve and controller complex to give a constant total flow in a stream.

DIAGRAM:



TOPOLOGY: < unit number > CONVAL = 1 -2

UNIT PARAMETERS:

Number required = 1

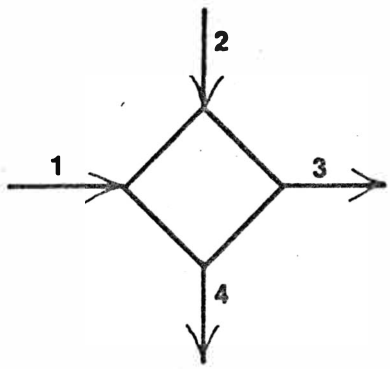
Parameter Number	Description
1.	Desired Flow

COMMENTS: CONVAL sets the input and output streams to the desired flow rate providing the input flow is greater than zero. If the input flow is zero, the output flow is set to zero. CONVAL does not affect any physical properties.

MODULE: DILUTR

PURPOSE: This unit takes one input stream and dilutes it with another input stream to a desired consistency of any set of components.

DIAGRAM:



TOPOLOGY: < unit number > DILUTR = 1 2 -3 -4

UNIT PARAMETERS:

Number required = 2, 3, or up to one plus the number of components.

Parameter No.	Description
1.	Desired mass fraction of the controlled component.
2.	Number of the first controlled component. (Component number plus seven.)
3.	Number of the second controlled component . . .
4.	Number of another controlled parameter. (Up to the total component list may be specified this way. Refer to comment 2.)

COMMENTS:

1. The first stream number in the topology must be the stream which must be diluted. The second input stream is the dilution stream. The first output stream is the diluted stream and the second output stream is the excess dilution flow. If there is a shortage of dilution flow, this strem is set to zero and all the dilution flow is used. No extra flow is added by this unit so care should be taken that enough dilution flow is present.

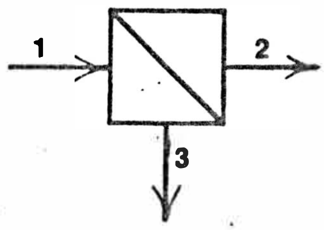
2. This unit will control one component or the combined sum of any number of components to a specified consistency, assuming that an adequate dilution flow exists. Error messages are written to device 7 if flow is inadequate or if the component to be controlled is more dilute in the controlled stream than the dilution stream.

3. The pressures of the output streams are the same as their corresponding input streams. For the controlled stream, a mixed enthalpy is computed, then a new temperature is computed.

MODULE: DYSSEP

PURPOSE: This unit models a screen, filter or paper machine wire.

DIAGRAM:



TOPOLOGY: < unit number > DYSSEP = 1 -2 -3

UNIT PARAMETERS:

Number required = the number of components contained in simulation

Parameter No.	Description
1.	Fraction of first component in input stream contained in accepts stream.
2.	Fraction of second component input stream contained in accepts stream.
.	
.	
.	
M	Fraction of Mth component in input stream contained in accepts stream.

COMMENTS:

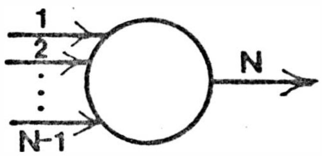
1. The first output stream in the topology is always the accepts stream or stream whose composition is specified by the unit parameters. The second output stream contains the rejects or material remaining from the input flow after the accepts are removed.

2. The split is assumed to be isobaric and isothermal.

MODULE: DYSMIX

PURPOSE: This unit models a pipe T or mixing point.

DIAGRAM:



TOPOLOGY: < unit number > DYSMIX = 1 2 ...N-1 -N

UNIT PARAMETERS:

Number required = Ø

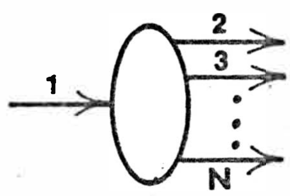
COMMENTS:

This module combines any number of streams into one. The temperature is computed from an enthalpy balance (no heat of mixing is allowed) and the pressure is set to the minimum of the inlet pressures.

MODULE: DYSTRB

PURPOSE: This unit models a distribution manifold.

DIAGRAM:



TOPOLOGY: <unit number> DYSTRB = 1 -2 -3 ...-N

UNIT PARAMETERS

Number required = number of output streams

Parameter No.	Description
1.	Percentage of input stream contained in first output stream.
2.	Percentage of input stream contained in second output stream.
.	
.	
.	
N	Percentage of input stream contained in Nth output stream.

COMMENTS:

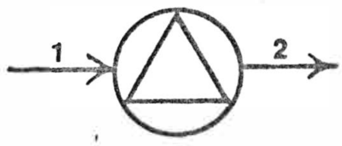
1. This module splits the flow of any stream into N output streams. Component fractions in the output streams remain the same as the input stream. The unit is assumed to be isobaric and isothermal.

2. If the specified splits do not add to unity, an error message is generated, but execution continues.

MODULE: FGEN

PURPOSE: FGEN is used to generate a sinusoidal, exponential, or pulse variation of any stream attribute or unit parameter as a function of time.

DIAGRAM:



TOPOLOGY: < unit number >   FGEN = 1 -2

UNIT PARAMETERS :

Number required = 6

Parameter No.	Description
1.	Type of function 1 = sinusoidal 2 = exponential 3 = pulse
2.	Controlled process. STREAM = Stream No. or UNIT = Unit No.
3.	Parameter No. or Attribute No. to be modified.
4, 5 and 6.	Interpretation depends upon function selected--See Comments.

COMMENTS:

1. When used to modify a stream attribute, the input and output streams can have the same identification number.

2. When used to modify a unit parameter, a dummy stream number must be supplied.

3. The name of parameter 2 is either "STREAM" or "UNIT and the value is the stream or unit number. Otherwise, parameter 2 is entered like all other parameters.

4. If parameter two is 1, then the sinosoidal variation is applied as follows: $V_N = V_o + A \sin \frac{(2\pi t)}{T_o}$

   where

   V_o = Initial value of the parameter = Parameter 4.

   V_N = New value of the parameter

   A = Amplitude of the variation = Parameter 5

   T_o = Period of oscillation = Parameter 6.

   t_i = Current simulation time.

   If parameter two is 2, an exponential variation is applied as follows:

   $V_N = V_o + A\, e^{B \cdot t_i} - 1$

   where

   V_N and t_i have the same meaning as above.

   Vo = Initial value of the parameter + Parameter 4

   A = Constant = Parameter 5

   B = Constant = Parameter 6

If parameter two is a 3, a pulse is applied as follows:

If $t_i < t_a = V_N$ = Current value of parameter

If $t_a \leq t_i \leq t_a + D$

V_N = Parameter value + S

If $t_i >$ ta + D

V_N = Current value of parameter

wherewhere

t_i, V_N have the same meaning as above

t_a = Time to apply the pulse = Parameter 4

D = Duration of pulse = Parameter 5

S = Size of pulse = Parameter 6.

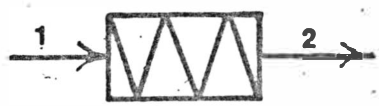
5. For the duration of the pulse, the modified parameter is held to its value at the time of application plus the height. At the end of the pulse duration, the parameter value is reset to the value at the pulse initiation.

6. Physical properties are recomputed if temperature is modified. Otherwise, FGEN does not affect physical properties.

MODULE: HEATER

PURPOSE: HEATER can mix several input streams together, then add a specific amount of heat or change the temperature.

DIAGRAM:



TOPOLOGY: < unit number > HEATER = 1 -2

UNIT PARAMETERS:

Number Required = 0 or 3

Parameter Number	Description
1.	Option
2.	Heat addition or temperature change
3.	Heat addition

COMMENTS:

If zero parameters are specified, HEATER acts like DYSMIX. The HEATER options are:

1. Heat added is heat/unit mass (k cal/m.t. for the PULP AND PAPER physical properties package.
2. Heat added is heat/unit time (k cal/time).
3. After mixing the streams, the resulting temperature is changed by the specified number of degrees. With this option, the required enthalpy change is

calculated and put into Paramter 3.

Parameter 3 need not be specified by the user. The unit will automatically set up the unit label and appropriate value. If the simulation is so small that a third parameter is not allowed, this calculation is ignored.

MODULE: MIXER

PURPOSE: The MIXER serves a variety of purposes. It can

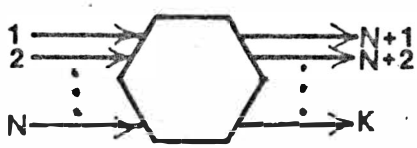
a) add multiple input streams together,

b) accumulate material,

c) add heat to the material in the mixer,

d) set up multiple output streams.

DIAGRAM:



TOPOLOGY: <Number> MIXER = 1...N -(N+1) ... -K

UNIT PARAMETERS:

Number required = 4+ number of components

Parameter Number	Description
1.	Temperature
2.	Pressure
3.	Total Mass in Mixer
4.	External heat flux in k cal/time
5.	Mass fraction of component 1

⋮

COMMENTS:

1. The heat addition to the MIXER can be positive or negative.

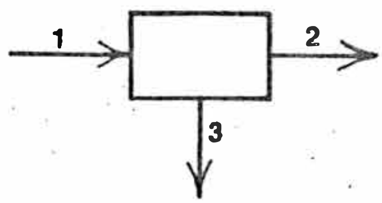
2. The output stream pressures are set equal to the MIXER pressure (Parameter 2), regardless of the input streams pressures.

3. The MIXER sums the flow of the input streams and puts this flow into each output stream along with the computer composition. If there is only one output stream, the MIXER acts as a constant mass (approximately constant volume) tank, with variable composition. If the MIXER has multiple output streams, these streams should be information streams or streams whose flow will be controlled by valves. In this case, the MIXER acts as a variable mass, variable composition tank. There is no limit on the accumulation of material in the tank.

MODULE: RGULTR

PURPOSE: This unit regulates the flow of a particular component or the total flow of a stream. Material is added by the unit if need be.

DIAGRAM:



TOPOLOGY: < unit number > REGULTR = 1 -2 -3

UNIT PARAMETERS:

Number required = 3

Parameter No.	Description
1.	Number of the component to be regulated
2.	Weight of the component to be in the first output stream.
3.	Weight of the component which must be added if not enough is contained in the input stream. (This parameter is calculated by the subroutine--the user initializes it to zero.)

COMMENTS:

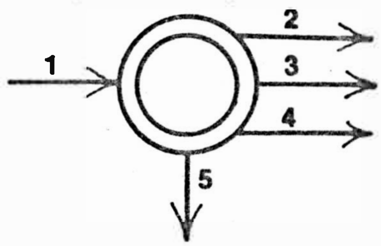
If there is excess input flow of the desired component, the required flow is put into the first output stream and the remainder is put into the second output stream. This split is assumed to be isobaric and isothermal.

If material must be added to obtain the required flow, it is added at the stream temperature. New component concentrations and a revised enthalpy are computed.

MODULE: SAVALL

PURPOSE: This unit models a disk type saveall. One input stream is normally divided into three output streams, clear filtrate, cloudy filtrate, and a cake. If the fiber fraction in the input stream becomes equal to a user specified consistency, the total input stream will be routed out a fourth stream.

DIAGRAM:



TOPOLOGY: <unit number> SAVALL = 1 -2 -3 -4 -5

UNIT PARAMETERS:

Number required = 8

Parameter No.	Description	Value
1	Fiber flag - position in stream array of fiber composition	9
2	Desired consistency of clear stream.	
3	Desired consistency of cloudy stream	
4	Percentage of input water in the clear and cloudy stream combined.	
5	Percentage of water in the clear and cloudy stream contained in the clear stream.	
6	Dump consistency -- critical consistency of input stream which, if reached, will cause the input flow to the SAVALL to exit through a designated stream.	
7	Percentage of filler in input stream contained in clear stream.	
8	Percentage of filler in input stream contained in cloudy stream.	

COMMENTS:

1. The first stream in the topology is the input stream. The first output stream is the clear stream, the second is the cloudy, the third is the cake, and the fourth is the sewer stream.

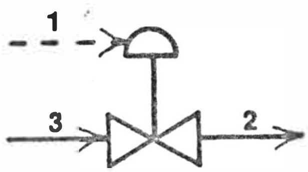
2. This unit works only with two or three components--water, fiber and, optionally, filler. Presently, this unit must have these components in a specific order. Water must be the first component, fiber the second, and filler the third. This is the only DYSCO subroutine which requires a specific component order.

3. The split is assumed to be isobaric and isothermal.

MODULE: VALVE

PURPOSE: This routine models a parabolic control valve. A signal from a controller is used to modify the valve throughout.

DIAGRAM:



TOPOLOGY: < unit number > VALVE = 1 3 -2

UNIT PARAMETERS:

Number Required = 2

Parameter Number	Description
1.	Valve Constant = C_V
2.	Valve Action = +1 or -1

COMMENTS:

1. If parameter two is +1, then a direct action valve is modelled. The flows in the input and output streams are computed as:

   Flow = Valve Constant · $(\text{Signal})^2$

2. If parameter 2 is -1, then an inverse action valve is modelled. The input and output flows are calculated as:

   Flow = Valve Constant · $(100 - \text{Signal})^2$

3. In specifying the valve constant, the user must remember that the flow is proportional to the square of the signal An appropriately sized valve constant must be used.

4. The valve operates without changing any stream attributes except the total flow. No pressure drop is calculated.

5. The input information stream (the signal) and the material stream (the flow) may be in either order.

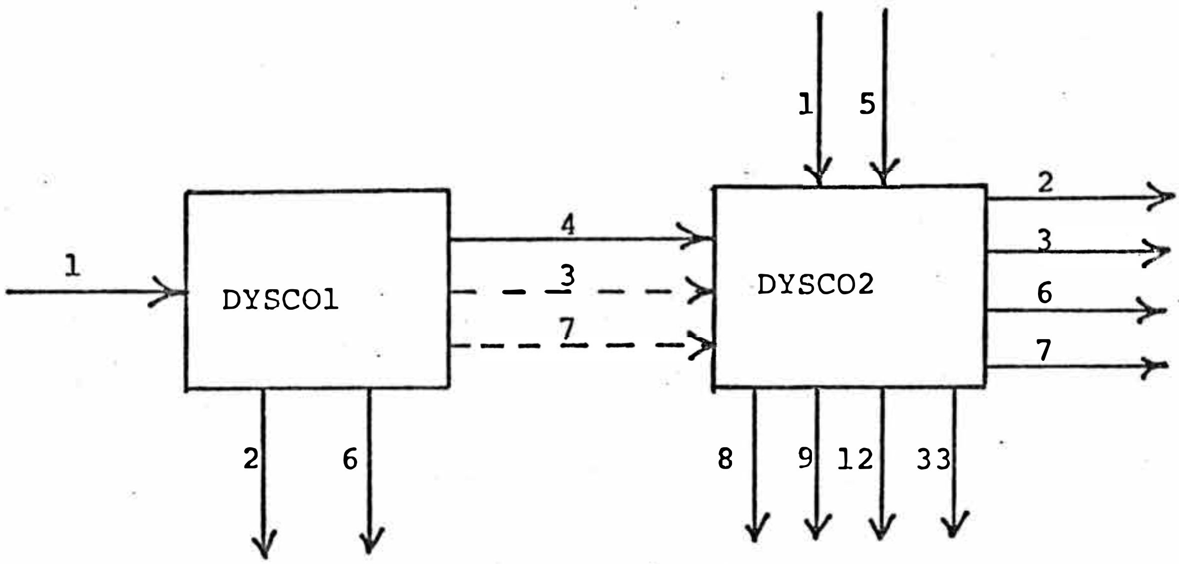
APPENDIX II

DYSCO FILE ASSIGNMENTS

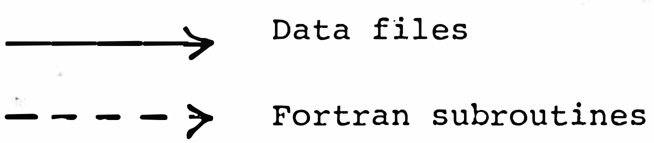
by

Dr. Peter Parker

APPENDIX II



1
DYSCO1
4
3
7
2
6
1
5
DYSCO2
2
3
6
7
8
9
12
33



Data files
Fortran subroutines

DYSCO1 FILES

Device No.	Type	Name	Function
1	Input	TESTTR4	Process topology in a free format
2	Output	DYS12	Prompting questions for entering process topology
3	Output	EQCAL	Not currently used
4	Output	DYS14	Summary of process topology written in a format suitable as input to device 4 in DYSCO2.
6	Output	DYS16	Prints errors in process topology, summari all input and output streams to the proces and prints all unused stream numbers.
7	Output	D1/DMAIN	A fortran subroutine containing all the process dimensions which is compiled and linked to DYSCO2

DYSCO2 FILES

Device No.	Type	Name	Function
1	Input	D/TEST1	Responds to questions and prompting from device #2 -- contains unit and stream parameters, unit calling order, and some control information
2	Output	D/TEST2	Asks for information from device 4, summarized it and writes it. Asks for unit and stream parameters and unit callin order from device #1
3	Output	D/TEST3	Summarizes information from device #1, and writes it in a format suitable to be used as device #1 input
4	Input	D/TEST4	Output file from DYSCO1. Contains the process topology
5	Input	D/TEST5	Answers to control information asked from device #6
6	Output	D/TEST6	Control questions
7	Output	D/TEST7	Error messages generated by unit subroutin

Continued DYSCO2 FILES

Device No.	Type	Name	Function
8	Output	D/TEST8	A summary of stream parameters at user specified intervals of time
9	Output	D/TEST9	Steady date unit and stream parameters written in the same format as device #1 and #3. If simulation is terminated before steady date is acheived then this file contains the latest values for these parameters
12	Output	D/TEST12	Informs user of timestep changes when using Adams-Moulton or variable step Runge-Kutta integration methods
33	Output	D/TEST33	Informatted stream and/or unit parameter values written at user specified intervals of time. (This file must be translated by another program before it can be read by the user)